ARE WE ESTIMATING A LIFE CYCLE MODEL OR AN ERROR CORRECTION MODEL?

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Using the recent developments in the econometric analysis of time series we find that a dynamic version of the life cycle hypothesis, which is observationally equivalent to the error correction model, is rejected for 11 OECD countries in our sample over the period 1951-1982. This is also supported by the pooled cross-section time-series data for the same countries. Hence, we favor the error correction model of consumption as the better approximation to the aggregate data generating process (decision making process) of consumers.

I. INTRODUCTION

Recent empirical evidence against the Life Cycle Hypothesis of consumption, generated by the analysis of patterns of saving during the retirement years, has induced remarkable interest in testing the implications of this hypothesis (see, for example, Kotlikoff, 1989, Hogarth, 1988 and their references). Nonetheless, Modigliani (1988, p.17) has argued that "a generalized life cycle model including both hump and inherited wealth will continue to exhibit all the basic macro properties of" his earlier model (see, for example, Modigliani, 1975). Hence, the validity of Modigliani's life cycle hypothesis model (denoted by LCH) as an appropriate approximation to the data generating process (decision making process) of consumers is at question. Indeed, many issues in the economics of consumer behavior and policy analysis rest upon the empirical adequacy of the life cycle model of consumption as the data generating process for consumers' expenditure.

The purpose of this paper is to test the life cycle model of consumption as it was expounded in Modigliani (1975) using cross-country data from OECD countries over the period 1951-1982. A novelty of this paper is the utilization of Davidson, Hendry, Srba and Yeo's (henceforth, DHSY, 1978) error correction model, as an alternative specification to the life cycle model. The error correction mechanism model was first introduced by Phillips (1954) for exploring stabilization policies in a closed economy. Later, this model was successfully applied to the UK wage data by Sargan (1964). DHSY's model is based on a "feedback theory" that allows consumers to behave as "backward looking" economic agents; i.e. basing their present consumption decisions on the past disequilibrium information (lagged savings). The error correction model (denoted by ECM) has been effectively applied to consumers' expenditure data from different periods and countries and has shown considerable degree of robustness (Hendry, 1983, Baltagi and Mokhtari, 1989, and Mokhtari, 1990). Resemblance of the ECM model and its estimated values to those of Modigliani (1975), Friedman (1957), Houthakker and Taylor (1970), Brown (1952) and Duesenberry (1949) are emphasized by DHSY and others. Gilbert (1986) and Mokhtari (1986) provide some of the relevant references.

In contrast to the ECM, the LCH model does not consider past savings, necessarily, as a mistakes or disequilibrium in consumers' consumption decisions. In fact, in the LCH savings are seen as a purposeful act by consumers to provide for the future. As an extreme (stochastic) implication of the life cycle hypothesis, Hall (1978) argues that, apart from a trend, consumption is a random walk process and that only innovations about the future influence consumers' decisions. Radical differences between the policy implications of error correction models and those of "forward looking" models are notable. In particular, if consumers are "forward looking" with respect to their consumption decisions government policies might be rendered ineffective.

Another novelty of this paper is the use of data conversion techniques developed in Kravis, Heston, and Summers (1982) that convert individual country data into an internationally comparable basis. Comparable data allow us to conduct our analysis on a country-by-country basis as well as in a pooled cross-country context. For our analysis, annual time-series data on real per capita private consumption expenditure and real per capita personal disposable income for eleven OECD countries over the period 1951-1982 are utilized.

Section II outlines the LCH and ECM models that are to be estimated and tested in this paper. Section III describes the application of Kravis et. al.'s technique in converting individual country data into an internationally comparable basis. Section IV presents the cross-country results for the life cycle - error correction models of consumption. Section V provides some concluding remarks.

II. MODEL

Life Cycle Hypothesis

There are many empirical studies on consumption and, as it is argued in DHSY's paper, most of these studies use a restricted version of a first order autoregressive distributed lag:

(1) $C_t = b_1 Y_t + b_2 Y_{t-1} + b_3 C_{t-1} + U_t$

Where C and Y are consumers' expenditure and

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disposable income, respectively; U is the (white noise) disturbances and bs are constant (parameters). In fact, a version of Ando and Modigliani's (1963) life cycle model is, observationally, nested in this specification. To see this, one may consider Modigliani's (1975) LCH that, in steady state, may be written as:

(2) $C_t = a_1Y_t + (a\text{-}r)A_t + U_t$

where A and r are private wealth and its rate of return, respectively; U is the reminder (disturbances) that is not explained by the life cycle hypothesis. If the LCH adequately accounts for all the systematic behavior in consumers' expenditure the reminder (U_t) should not contain any discernable structure; that is, U_t should follow a random behavior (e.g., white noise process). Given that in empirical implementation of the above equation, a_1, a and r are usually held constant, (2) can be written as:

(2)' $C_t = a_1Y_t + a_2A_t + U_t$

Where a_2=(a-r) is a constant. To test (2) as an adequate approximation to the decision making process of consumers, when accurate and sufficient observations on consumption expenditure, income and wealth are available, one would estimate the LCH model and check on its validity on the basis of **a priori** expectations about the coefficients and the residuals. A measure of such **a priori** expectations is that the estimated residuals should assume a random behavior, such as a white noise process that contains no systematic information. So, given adequate and reliable observations on the included variables, U_t might be tested against the properties of a white-noise process. However, data on assets, when available, are highly unreliable. Hence, "it may be preferable to rely on proxies or on methods that do not require the use of asset data" (Deaton and Muellbauer, 1980, p. 325). Given the paucity of asset data a transformation of (2)' that does not involve A_t has been the subject of estimation and inferences; e.g., see, Spiro (1962), Ball and Drake (1964) and Evans (1967) who estimate a differenced version of (2)', while, approximating the change in A_t by $(Y\text{-}C)_{t\text{-}1}$, when there are no capital gains. Differencing (2)', and substituting $(Y\text{-}C)_{t\text{-}1}$ for the change in A_t we obtain:

(3) $(1\text{-}L)C_t = a_1(1\text{-}L)Y_t + a_2(Y\text{-}C)_{t\text{-}1} + (1\text{-}L)U_t$

where L is the lag operator such that $LX_t = X_{t\text{-}1}$. Following Modigliani (1975), (Y-C) can be interpreted as the stationary change in the liquid assets. Note that, now, (3) possess a first order moving average error term rather than a simple white noise process. Nonetheless, given the above assumptions, (3) is consistent with Modigliani's original model (2). Observationally, with $b_1 = a_1$, $b_2 = (a\text{-}r)\text{-}a_1$, and $b_3 = 1\text{-}(a\text{-}r)$, (3) is a nested model in (1).

A crucial point is that the error term in (3), which is an unobservable variable, is a moving average process. Hence, structure of the residuals in (3) allows us to identify between the rival models at a finer stage of the model selection process.

Error Correction Mechanism

A simple error correction model of consumption, derived by Davidson et al. (1978) is based on the "feed-back" theory. This theory modifies short-run proportional changes of C with Y by utilizing the feed-back from past disequilibrium (Y-C). This ensures the proportionality of C and Y in a static (long-run) equilibrium. Accordingly, an ECM model is written as:

(4) $(1\text{-}L)C_t = d_1 (1\text{-}L)Y_t + d_2 (Y\text{-}C)_{t\text{-}1} + U_t$

where ds are constant (parameters) and U is a white noise process.

Similarly, rearranging (1), and imposing

$$b_1 + b_2 + b_3 = 1$$

one obtains DHSY's ECM model of consumption

(5) $(1\text{-}L)C_t = b_1 (1\text{-}L)Y_t + (1\text{-}b_3) (Y\text{-}C)_{t\text{-}1} + U_t$

where, the error term preserves its original (white noise) properties.

A feed-back theory explanation of (5) states that consumers plan to smooth out their consumption expenditures by consuming b_1 out of the change in income, $(1\text{-}L)Y_t$, and $(1\text{-}b_3)$ out of the disequilibrium term (past savings), $(Y\text{-}C)_{t\text{-}1}$. This ensures proportionality of the consumption and income in the long-run. In the short-run, validity of the ECM model rests upon the significance of the error correction term; i.e., $(Y\text{-}C)_{t\text{-}1}$. In the long-run, where the short-run dynamic reaction between consumption and income has been worked out, the disequilibrium term should not be of any significance. This means that $(1\text{-}b_3)$ is expected to approach zero (or that savings are of no importance in the long run). Hence, in the absence of a significant disequilibrium term, equal rate of growth in income and consumption will lead to a long-run value for b_1 that should not be significantly different from one. Baltagi and Mokhtari (1989) provide pooled cross-section time-series estimates that support this proposition. However, in the short-run without full adjustment to the rate of growth in income ($b_1 < 1$), the disequilibrium term (Y-C), could change to accommodate the shocks, i.e. leading to a significant $(1\text{-}b_3)$.

The distinguishing factor between (3) and (5) is the existence of a moving average process in the LCH model and lack of it in the ECM representation. Hence, in section IV, the null hypothesis of a simple moving average will be tested. Additionally, the null hypothesis of a random walk process (existence of a unit root) in the residuals of (2) will be tested. Rejecting these null hypotheses are taken as the support for the alternative hypothesis of a white noise residuals.

III. DATA

For an international analysis, comparable data (in the same unit of currency) are of extreme importance. The lack of internationally comparable data could reduce the researcher's ability to conduct a thorough analysis of the relevant data. This is more notable when a comparison of 'level' is of importance or, when 'ratios' are being compared (when denominator and numerator are subject to different conversion factors). However, models cast in the rate of growth of variables or ratios (when denominator and numerator are subject to the same conversion factor) have the potential of circumventing the above problem. When these types of models include an intercept, or dummy variable, magnitudes become important, and the level of variables having internationally comparable units becomes vital. Moreover, we should note that comparable values are the basic input to the application of pooled estimation techniques. Hence, the importance of comparable data for our analysis is clear.

Following the monumental work of the International Comparison Project (ICP), by Kravis et al. (1975, 1978, 1982), we have used their results in converting consumption and income data to internationally comparable levels. Utilization of the ICP results has provided us with the opportunity to circumvent the usage of the exchange rate that is known to be notoriously inaccurate as a conversion factor.

A simple application of the ICP method for achieving internationally comparable time series would be to allow aggregates or sub-aggregates of national accounts derived by the ICP method to be extrapolated at the rate in which their available counter part grow over time.

As an example if X_{tm}, P_{tm}, PPP_{t0m} and f_{t0x} are a per capita time series in current prices, price deflator, related purchasing power parity on time t_0 and international prices of x at time t_0, then the internationally comparable values of x_{tm} (i.e. real values of X) and P_{tm} could be computed as follows:

$$X^{*} = (x_{t0m}/PPP_{t0m}).f_{t0x}.((1-L)x_{tm}/x_{tm})$$

and

$$P^{*} = P_{tm} \,.\, PPP_{t0m}$$

for $x_{tm} = X_{tm}/P_{tm}$, $P_{tm} = P_{tm}/P_{t0m}$, $t=1,...t_0,...T$, $m=1,...M$, where X^{*}_{tm} and P^{*}_{tm} are internationally comparable values of X_{tm} and P_{tm}, respectively, and t_0 is the benchmark year for which purchasing power parities (PPP) and international prices (f) are available. Notice that x_{t0m}/PPP_{t0m} might be considered as the so-called "notional quantity" with the qualification that this is "not strictly quantities but rather values of quantities at numeraire country [U.S.] prices" [Kravis, et al., 1982, pp.172].

IV. ARE WE ESTIMATING A LIFE CYCLE MODEL?

To realize that if we are estimating the LCH or the ECM representation of the data we must use the structure of their residuals as the criteria for the model selection. In this regard testing for the null hypothesis of a moving average and a random walk (unit root) process in the residuals will give a substantive indication as to which model is the appropriate approximation to the decision making process of consumers. Note that, finding a random walk process in the estimated residuals of a regression can, potentially, reveal misspecification that might be due to the exclusion of a nonstationary variable from the set of relevant regressors. On the other hand, rejecting the existence of a random walk process in (3) favors the alternative hypothesis of a stationary process that is consonant with the above models.

While Durbin-Watson statistic (DW) is known to be a test for detecting serial correlation, it is, also, a robust test against other alternatives such as a moving average process. Moreover, Sargan and Bhargava (1983) suggest this statistic for detecting random walk behavior (unit root) in economic variables and provide the relevant critical values. DW tests, reported in Table (1), reject the null of a simple moving average for all of the countries in our sample. DW for the pooled estimates supports these findings. While, various tests are proposed for detecting unit roots in the economic time series, Dickey and Fuller's (1981) t-test and Sargan and Bhargava's DW-test are the easiest to apply. Dicky and Fuller (1981) provide a t-statistic (DF) that tests for the null hypothesis that errors in a regression model follow a random walk process (i.e., possess a unit root). To test for a random walk process using DF-statistics, we check U_t for the existence of a unit root by running the following regression:

$$(1-L)U_t = d\, U_{t-1} + v_t$$

where v_t is assumed to follow a white noise process. A negative and significant d value implies that the null hypothesis of a random walk process can not be rejected. To test for the significance of d at the five percent level of significance, the critical value of 1.96 is used (see Fuller, 1976, p.373). Dicky and Fuller's test can be improved upon by augmentation to allow for higher order autoregressive processes, e.g. $(1-L)U_{t-1}$, (see, Granger and Newbold, 1986, p.263). Augmented Dick and Fuller's test is denoted by ADF and should be compared with a critical value of about 3. Table (1) presents the estimates of DF- and ADF-statistics for the above specification. Values of the DF- and ADF-statistics larger than critical values strongly reject the null of a random walk process in the estimated residuals. Indeed, we obtain no values less than 3.3 for the above t-tests.

Given that the Dickey-Fuller tests are sensitive to whether the null hypothesis being tested is a pure random walk process or a random walk process with a drift we have also reported Sargan and Bhargava's (1983) test (DW) for the unit root. Sargan and Bhargava show that the DW statistic is invariant to the null hypothesis of a pure random walk process or a random walk process with a drift and provide the relevant critical values for this (DW) test. Bhargava, Franzini and Narendranathan (1982) have suggested DW for testing unit roots in panel data. Comparison of country-by-country DW values with the critical value of .77, reported in Sargan and Bhargava for the five percent level of significance, support the above findings. These are, also, supported by the pooled cross-section time-series results that are reported in Table 1. Note that the relevant critical value for the pooled DW value is .25. Overall, our estimated model appear to be the error correction model of consumer behavior that is proposed in the DHSY (1978) paper.

Table 1. Life Cycle Model vs. Error Correction Model
Dependent Variable: Change in consumption expenditure ($(1-L)C_t$)

Country	$(1-L)Y_t$	$(Y-C)_{t-1}$	R2	DF	ADF	DW
U.S.A	.45 (14.30)	.02 (5.86)	.87	-3.75	-4.63	1.39
Japan	.41 (9.38)	.03 (4.17)	.68	-4.83	-4.53	1.69
Austria	.43 (6.31)	.01 (2.13)	.42	-6.39	-3.36	2.32
Belgium	.36 (9.04)	.03 (6.41)	.77	-6.84	-5.47	2.46
Denmark	.42 (8.49)	.009 (1.67)	.67	-5.41	-4.14	1.96
France	.32 (8.19)	.04 (9.60)	.76	-5.96	-4.15	2.20
W. Germany	.42 (10.90)	.02 (5.27)	.71	-5.20	-4.95	1.90
Ireland	.40 (4.89)	.01 (.88)	.40	-6.23	-4.11	2.03
Italy	.45 (10.51)	.02 (4.22)	.75	-4.50	-5.05	1.53
Netherlands	.42 (6.76)	.02 (2.85)	.60	-5.59	-3.86	2.01
U.K.	.52 (7.64)	.006 (1.06)	.64	-4.90	-4.40	1.64
			POOLED RESULTS			
OLS	.43	.02	.68	-16.63	-	1.83
	(28.6) [22.22]	(11.25) [7.79]				

(.) OLS t-values.
[.] Heteroscedasticity-Consistent t-values (see, White, 1980).

Further Results

Assuming that the estimated coefficient in Table 1 are those of an ECM model, we can make the following observations:

- The country-by-country and pooled estimates of the short-run marginal Propensities to consume are around 40 percent. It should be noted that, since, throughout our analysis, application of the pooled Within estimator (i.e. Least Square Dummy Variable technique) provided similar estimates as those of the OLS technique, we have not reported these estimates.

- Consumers' expenditure adjust to the past disequilibrium by about 2 percent, as is indicated by the individual country values and the pooled results. But, note that this is not, strictly, true for all of the countries.

- Denmark, Ireland and the U.K. do not show a statistically significant error correction term; i.e. $(Y - C)_{t-1}$. Hence, appropriateness of the ECM model (5) as the data generating process for consumers' expenditure in these three countries is rejected.

V. CONCLUSION

This paper provides country-by-country and pooled cross-section time-series evidence on the estimation and testing of the life cycle model of consumption as it was expounded in Modigliani (1975). As an alternative to this model we utilized Davidson, Hendry, Sarba and Yeo's (1978) error correction model, which assumes consumers are "backward looking". Using Durbin-Watson statistic and some of the recent developments in testing unit roots we found that a dynamic version of the life cycle hypothesis is uniformly rejected for all of the 11 OECD countries in our sample. As a result we favor the error correction model of consumption as the better approximation to the decision making process of consumes. Our estimates of the ECM model show that about 40% of the shocks to income are absorbed by the consumers upon impact; and that it takes some time for the rest of the adjustment to occur.

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